ME 370
Vibration of Mechanical Systems
Fall 2025, Section 2

Time: MWF 12:20 PM – 1:10 PM / **Location:** 129 Waring Hall

INSTRUCTOR: Dr. Joseph S. Najem
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Office Hours: 1:30-4:00 PM on Wednesdays and Fridays in person or on Zoom (https://psu.zoom.us/my/josephnajem)

**Meetings outside office hours are by appointment only and upon availability.*

**Office hours can be in person or via Zoom (you need to let me know if you plan to meet on Zoom)*

**I will respond to your emails only between 8 am and 5 pm, Monday through Friday.*

Textbook: Engineering Vibration, Fifth Edition, Inman, Daniel J., Pearson, 2022

a. Other supplemental material: None

Course Description: Complex machines and structures often produce vibrations as they operate. Such vibrations are undesired as they could shorten the life of equipment, decrease its effectiveness and precision, or produce an unpleasant noise. This course will cover various ways to detect, prevent, and dampen vibrations. We will cover the modeling and analysis of vibration characteristics of mechanical systems with single degree and multiple degrees of freedom. Further, we will study the vibration characteristics of mechanical systems and vibration control. The course is divided into four main topics. Fundamental aspects of mechanical vibrations are studied first. Types and causes of various vibratory motions are described. The concepts of mathematical modeling of the vibratory systems are presented. Model elements, including mass/inertia, spring, and damper elements, and their corresponding describing equations are studied. Single-degree-of-freedom vibrations are modeled and analyzed. Equations describing free vibrations of undamped and damped systems are derived. Natural frequency and damping ratio are defined, and their physical significance is discussed. Harmonically excited vibrations are studied with many practical application problems; resonance and its physical significance are emphasized. The theoretical aspects of general periodic vibrations and non-periodic vibrations are formulated by means of Fourier analysis and the convolution integral. Vibrations of multiple-degree-of-freedom systems are studied. Mathematical models governing free vibrations are formulated. Equations determining the natural frequencies and mode shapes of the system are derived in relation to eigenvalue problems. Harmonically excited vibrations are analyzed with practical applications. Vibration control in relation to engineering design is the last topic studied. Various vibration control concepts and techniques are presented, including vibration isolation, vibration absorption, and balancing to reduce the intensity of the source of excitation.

Prerequisites: EMCH 212, CMPSC 200 or 201, MATH 220 and 251

Computer requirements: MATLAB will be used to obtain numerical solutions and for plotting

Goals and Objectives:

a. Course Instructional Outcomes [Mapping to Student Outcomes shown in brackets]:

1. Understand and appreciate the benefits of mathematical modeling and analysis [SO1]
2. Develop proficiency in setting up suitable models of mechanical hardware [SO1]
3. Gain first-hand experience of the analysis process [SO1]
4. Understand the physical and mathematical significance of natural frequencies and mode shapes, free and forced response, resonance, Fourier analysis, convolution integral, damping, superposition, lumped parameter vs. continuous systems, and linear vs. non-linear systems [SO1, SO4, SO7]
5. Improve mathematics skills [SO1]
6. Understand current vibration issues [SO4, SO7]

b. Student Outcomes:
SO1: An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
SO4: An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, and social contexts.
SO7: An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Resources:
Canvas

Course Topics:

1. Fundamentals of mechanical vibrations: (3 weeks)
    - Introduction, types of vibratory motion
    - Modeling of vibratory systems, degrees of freedom
    - Model elements, mass/inertia, spring, and damper
2. Single degree-of-freedom vibrations: (6 weeks)
    - Free vibrations of undamped systems
    - Free vibrations of damped systems
    - Harmonically excited vibrations, design considerations
    - Vibration isolation
3. Multiple degree-of-freedom vibrations: (3 weeks)

- Free vibrations and principal modes
- The eigenvalue problem
- Forced vibrations
- Vibration absorption

4. Vibrations with non-harmonic excitations (3 weeks)

Grading Policies:

This course will follow all policies and rules as outlined in Senate Policy 47-20. Occasionally, a disagreement arises in the assignment of a grade. A student who wishes to question or challenge the grade assigned must email a request for a grade change, including a copy of the question, the original answer, and a paragraph explaining why a grade change is warranted.
On the rare occasion that a student and instructor fail to resolve the course grade dispute through informal means, the student may request that the head of the academic program offering the course review the issue and take appropriate action to mediate and seek resolution. If this does not resolve the dispute, the student may seek further review from the associate dean for undergraduate or graduate education or the director of academic affairs for the college offering the course. The student may initiate this process by completing the Grade Adjudication Petition Form (available at http://www.psu.edu/oue/aappm/grademed.pdf) and returning it to the associate dean or director of academic affairs responsible for undergraduate education, or the associate dean for graduate studies. The request form must be submitted no later than ten weeks following the end date of the course (as it appears in the schedule of classes).

Evaluation & Grading:
Students will earn points for weekly homework and quizzes, two tests, and a final examination. Homework should be submitted at the start of class on the due date. Your homework is ***required*** to be a printed, word-processed document, as this is what will be expected of you when you go to work. If you do not know how to use an equation editor and/or MATLAB, it is time to learn how, as these will be invaluable tools for you once you graduate.

Formulas and weights for assignments, quizzes, and exams:

Homework (Assigned every Friday and due the Friday after)	10 %
Quizzes (drop the lowest grade) (Every Friday unless otherwise specified)	20 %
Tests (25% will go to the highest grade)	40 %
Test 1: October 8 | 12:20 pm - 1:10 pm | 129 Waring	
Test 2: November 19 | 12:20 pm - 1:10 pm | 129 Waring	
Final	30 %

Grading Scale:

Final Course Average	Grade
<65.00	F
65.00≤avg≤75.00	D
70.00≤avg≤77	C
77.00≤avg≤80	C+
80.00≤avg≤83	B-
83.00≤avg≤87	B
87.00≤avg≤90	B+
90.00≤avg≤93	A-
93.00≤avg≤100	A

Policies for missed projects/assignments:

Students will only be allowed to make up missed work for legitimate, unavoidable reasons, such as illness, injury, military service, family emergency, or religious observance.
Non-legitimate missed work will receive a zero.

Policies for make-up quizzes and exams:

Suppose an evaluative event will be missed due to an unavoidable absence. In that case, the student should contact the instructor as soon as the inevitable absence is known by email or in person to discuss ways to make up the exam.
44-35 CONFLICT OF NON-FINAL EXAMINATIONS

1. Evening Conflict. In the case of conflict between an evening examination or quiz and other scheduled University-approved activities, or in the case of more than one evening examination in any one evening, each student is permitted to make up the examination without penalty.
2. Non-Evening Conflict. In the case of conflict between a non-evening examination or previously announced quiz and participating in scheduled University-approved activities, the student is permitted to make up the examination or quiz without penalty.

Attendance and late policies:

Religious observances are not counted as absences, though observing students must inform the instructor during the first week of the course of any planned absences. Official university activities are excused absences if the student notifies the instructor in advance and provides appropriate paperwork. Absence due to sickness does not require a doctor's note. Still, it is the student's obligation to inform the instructor promptly and to bring to the instructor's attention extended medical absences as soon as possible. It is the responsibility of the absent student to catch up on any missed material and do any make-up work required by the instructor.

Academic Integrity:

The University defines academic integrity as the pursuit of scholarly activity in an open, honest, and responsible manner. All students should act with personal integrity, respect other students' dignity, rights, and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts, refer to Senate Policy 49-20. Dishonesty of any kind will not be tolerated in this course. Students who are found to be dishonest will receive academic sanctions and will be reported to the University's Office of Student Conduct for possible further disciplinary sanctions (refer to Senate Policy G-9).

Dishonesty Examples:

CHEATING is a general category of academic misconduct that, in the context of an academic course, involves dishonesty in completing work in the course, whether an examination or other kind of assignment. Assisting another student dishonestly is also cheating. Note that plagiarism, fabrication of research results, and other such violations of academic integrity may correctly be identified as particular kinds of cheating.

Examples of cheating include, but are not limited to, the following:

- Knowingly discovering or attempting to discover the contents of an examination before the instructor releases the contents
- Taking a picture of or otherwise copying an examination without permission to do so
- Providing such a picture/copy to another person
- Obtaining, using, or attempting to obtain or use any material or device dishonestly
- Supplying or attempting to supply any material or device to another person dishonestly
- Obtaining or attempting to obtain unauthorized information during the course of an examination from another student or another student's test materials
- Unauthorized possessing, taking, copying, or sharing of solutions manuals or computerized solutions (example CHEGG) for assigned homework or research problems
- Taking a quiz, an exam, performing a laboratory exercise, or similar evaluation in place of another.
- Altering an exam, quiz, project, or lab by changing incorrect answers and seeking a grade adjustment, asserting the instructor made a mistake in grading.

- Facilitating acts by others; unauthorized collaboration of work; permitting another to copy; writing a paper for another; inappropriately collaborating on home assignments or exams without permission or when prohibited.

PLAGIARISM is that kind of cheating that involves using someone else's words, ideas, or other intellectual property as if they (the words, ideas, or other intellectual property) were one's own original work. Some common kinds of plagiarism are listed here:

- Because the richly varied resources of the Internet make copying the work of others easy, a particularly common kind of plagiarism occurs when someone reproduces or closely imitates one or more documents from the Internet and claims that the resulting essay or research paper is the copier's own work.
- Similar issues of dishonesty are raised by term paper sites or custom term paper writing services, where one can purchase a term paper, research paper, or essay.
- Submitting as one's own an assignment prepared by another student is an obvious form of plagiarism.
- At other times, plagiarism occurs because a student does not understand the necessity or the mechanisms for acknowledging the words, ideas, or other intellectual property of others.

FABRICATION is cheating by faking results, as of an experiment, or otherwise "making up" something that one presents as true, factual, or real. Fabrication in an academic context may occur in a number of forms, including these:

- falsifying research results or a report of research processes
- falsifying reports or records related to a field, practicum, or clinical experience

Disability Resources:

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. Student Disability Resources (SDR) website provides contact information for every Penn State campus http://equity.psu.edu/sdr/disability-coordinator . For further information, please visit Student Disability Resources website http://equity.psu.edu/sdr/ .
To receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: See documentation guidelines (http://equity.psu.edu/sdr/guidelines). If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

Counseling & Psychological Services (CAPS):

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional well-being. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a

philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

- Counseling and Psychological Services at University Park (CAPS) (http://studentaffairs.psu.edu/counseling/): 814-863-0395
- Penn State Crisis Line (24 hours/7 days/week): 877-229-6400
  Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741

Educational Equity/Report Bias

Penn State University has adopted a Protocol for Responding to Bias Motivated Incidents http://equity.psu.edu/reportbias/reports/protocol-for-responding-to-bias-motivated-incidents that is grounded in the policy that the "University is committed to creating an educational environment which is free from intolerance directed toward individuals or groups and strives to create and maintain an environment that fosters respect for others." That policy is embedded within an institution traditionally committed to academic freedom https://guru.psu.edu/policies/OHR/hr64.html. Bias-motivated incidents include conduct that is defined in University Policy AD 91: Discrimination and Harassment, and Related Inappropriate Conduct https://guru.psu.edu/policies/ad91.html . Students, faculty, or staff who experience or witness a possible bias-motivated incident are urged to report the incident immediately by doing one of the following:

- Submit a report via the Report Bias webpage (http://equity.psu.edu/reportbias/)
- Contact one of the following offices:

  University Police Services, University Park: 814-863-1111

  Multicultural Resource Center, Diversity Advocate for Students: 814-865-1773

  Office of the Vice Provost for Educational Equity: 814-865-5906

  Office of the Vice President for Student Affairs: 814-865-0909

  Affirmative Action Office: 814-863-0471

  * Dialing 911 in cases where physical injury has occurred or is imminent